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MODELLING AS A TECHNIQUE TO AID ALTERNATIVE CONCEPTIONS IN PHYSICS

R. K. Nayak

PGT (Physics), DMS, RIE, Shyamla Hills, Bhopal, India.

ABSTRACT

A case study was conducted taking a group of 27 class 12 students of DMS, Bhopal to explore the effectiveness of modelling technique called *'Tractor vs. Car and Tall man vs. Child'* as a classroom technique to help students form alternative conceptions about abstract concepts in physics. An attempt was made to look at the existing refraction and dispersion related concepts of the students through iterative inquiry approach. The conceptions of students about dispersion were explored through a series of inquiry questions like: what is dispersion? What is the sequence of appearance of colours on the screen after dispersion of white light by a prism? What are the probable reasons for such appearances of colour? What may be the basic causes of dispersion? What are the laws of refraction? Do they find situations in their daily life similar to refraction? Though students had already studied the concepts, still most of them could not comprehend reasonable and logical answers to most of the questions. At best they could recall some stray answers which they could not defend when cross fired with counter questions. Later on a modelling technique called *'Tractor vs. Car and Tall man vs. Child'* was introduced to help students form alternative conception about the phenomenon called refraction and dispersion. Daily life situations like students in play ground, students exiting from school as the last bell goes, a car obliquely entering a patch of sandy road from concrete path were part of modelling techniques used in class. This enabled all students to form concepts like what happens to the direction of path of light when it travels from rarer medium to denser medium and vice versa; most of them could demonstrate their understanding through reasonable and logical answers to all sorts of critical counter questions.

KEY WORDS: Modelling, Alternative Conception, Refraction, Dispersion.

INTRODUCTION:

The succession of our thoughts is not arbitrary, but governed by laws- sometimes those of association, sometimes those depending upon a purpose in our thinking (Russel, p.503). Modelling situations using quantities, shapes and forms are the best use of mathematics (NCF 2005, p.44). This is important as an application of determinism to mathematics. I suggest the use of induction for arriving at general laws in physics. As against Plato, Hobbes holds that reason is not innate, but is developed by industry (Russel, p.504). I tried to understand the attitude towards concepts of physics through Hobbe's lens. Due to the interactions between the objects in a system or with objects outside a system, the system may change in some manner. However, in a traditional physics class students do not have a clear understanding of what the word model means, and thus do not appreciate the role of this notion in physics (Harrison and Treagust, 2000). In physics education, modeling of phenomena for investigations and problem solving has been done mostly by Hestenes and his colleagues(Etkina, Warren, and Gentile, 2006).

OBJECTIVES:

(i) To explain the concepts related to laws of refraction, dispersion, and refraction with the help of modelling the process.

(ii) To encourage students to use modelling as a technique to connect known situation to abstract concepts.

HYPOTHESIS:

(i) Students face difficulty in recalling, comprehending and applying the concepts and facts related to the laws of refraction, dispersion, and refractive index of material with respect to different colours.

(ii) Modelling of process technique can help the students in construction of knowledge about these concepts; they can recall, relate, and apply the concepts with ease.

METHODOLOGY:

This is a case study with one section of class 12 physics students. There were 28 students. Iterative inquiry approach was used to explore the depth of their understanding about the concepts like laws of refraction, dispersion, and refractive index of medium with respect to different colours. Intervention in the form of a model of an interaction was designed and given to the section of students in about 40 minutes. The entire process constituted 70 minutes.

Intervention:

Modelling situation for convex/concave:

Teacher wanted to know whether students were well versant with the terms used in optics. You know what is optics; one student – light. I think you have studied the concepts like convex, concave and plane mirror. Teacher curved his own palm and showed the students (the part caved in). Think the backside skin is the silver coating and my palm is made up of glass. What type of mirror is it? There were mixed response from class. The teacher asked each group of students to support their answers with logic. One student tried but failed to connect the concept. Teacher gave them the hint to analyse the word CONCAVE as CON - CAVE; Cave means gumpha (the portion bulged in). Look the palm is bulged in (not out); so its concave. The teacher rotated the palm; this time the outer part of the curved palm faced the students; look this part is bulged out (like the outer of foot ball). Now if its silvered from inside that is the concave part then it behaves as convex mirror. For example, if you sit inside a foot ball, then concave part is visible; if you look from outside convex part is viewed. The centre of foot ball is centre of part cut from it (convex or concave mirror). What is the difference between mirror and lens? What happens when light is passed through a prism?

When a screen is placed behind the prism, in which sequence VIBGYOR is found; top – Red or bottom – Red. Students opinions were divided. Can you provide tentative explanation for why do expect RED at the top of screen or VIOLET at the bottom? Student response: red colour has maximum wavelength; so what (teacher). Students could not comprehend that due to maximum wavelength RED deviates minimum from path. What ability the prism has hot so as to be able to disperse the light? Do all colors of light travel inside the medium (say glass) with same velocity? Assume that the entire world does not know about the velocity of different colors in glass; let us try to theoretically predict their relative velocities in glass from their wavelength. We know that red has maximum wavelength and violet has minimum wavelength. Let us relate to a daily life situation – Tractor with large wheels and a car with small wheels. Imagine both were moving with same speed on plane concrete road and all of a sudden a patch of muddy rough road came; tractor's speed remains less affected in comparison to car. Meanwhile the car with small wheels is likely to deviate (teacher deliberately use this word) from its original path more in comparison to tractor with large wheels. Its something like large wheel of tractor likely to interact less with the muddy road; since its wheel undertakes lesser number of rotations as compared to car to traverse a fixed path. The large wheel of tractor can be modelled with larger wavelength of RED and small wheel of car can be modelled with the smaller wavelength of VIOLET. The way a tractor can travel a rough patch of road with more speed and less deviation taking into advantage of its larger wheel size as compared to a car with smaller wheel size; the same way RED colour is supposed to travel at more speed and less deviation compared to VIOLET colour. Another thing whenever speed would be more deviation would be small. You can think of two cyclists one with large speed and other small entering into a patch of sandy road/ a patch full of water all of sudden from pucca road; what is expected the cyclist with larger speed is less likely to deviate from its original direction and the cyclist with smaller speed is more likely to deviate from the original direction. Another situation may be a tall man and a child trying to make their way through a crowded place; its more likely that the tall man can disperse the crowd easily and less likely to deviate from its path; whereas the child is more likely to get deviated from its path. Tall man is modelled as larger wavelength of RED colour and child as smaller wavelength VIOLET colour. Red colour is least deviated and violet is most deviated.

Modelling situation for Laws of Refraction:

Imagine the two front wheels of a car entering rough patch of road from concrete road. Wheel A enters the rough patch earlier to wheel B; speed of wheel A reduces

where as speed of B remains as it is. Keeping in mind the centripetal force the car is likely to turn towards A; this situation is compared with light travelling from RARER medium to DENSER medium bends towards normal. Similar way the converse situation can be described; light travelling from DENSER to RARER medium bends away from normal.

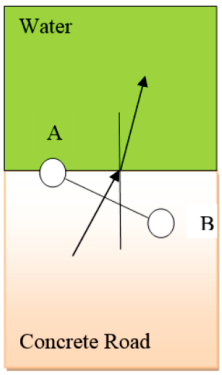

Figure1: Refraction

RESULTS AND DISCUSSION:

When students were asked simple factual questions like: what is dispersion? Most of the students were not able to relate their physics terminologies to their daily life situation. About 8% students were little bit aware of the concepts and few terminologies. Short versions of long definitions were provided along with connections to daily life situations. I told them to search for similar vocabularies from their daily life; several examples were put to show the relation between daily life situation and terminologies used in optics. They could connect the concepts and construct knowledge. Almost everybody was participating in the iterative inquiry. They were thinking and giving their versions of interpretation. At times I was correcting with their help the missing links in their argument. They were made to visualise the basic cause of dispersion. Do all the colours of light travel with same velocity in a glass? Why? They had an answer now. Right from RED colour to VIOLET colour must have wavelength in descending order (Given the fact that on screen placed behind prism VIBGYOR is from bottom to top). Students could relate and counter relate wavelength, deviation, speed, refractive index of material, change in direction of path due to refraction with the help of modelling the respective situation. Several modelled situations were used to firmly establish the connection between different concepts.

CONCLUSIONS AND IMPLICATIONS OF THE STUDY:

Modelling of interaction proved to be a potential and effective tool to initiate students to new abstract concepts in optics. It encouraged students to construct their concepts through connection to known and comprehensible physical situations; they could get conversant with the concepts and phenomena; they could respond to critical questions related to optical phenomena. The modelling of interactions is rather subjective in nature which needs to be handled and steered keeping in mind the step by step participation of students in drawing logical conclusions. The teacher needs to have a wide range of knowledge to form critical questions related to the concept so as to create cognitive conflict; to resolve these conflicts teacher would make intelligent use of modelling. It makes the students curious, arouses interest towards physics, and creates small continuous challenges for them.

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